ON

THE MORPHOLOGY

OF

THE REPRODUCTIVE SYSTEM

OF THE

SERTULARIAN ZOOPHYTE,

AND ITS ANALOGY WITH THE REPRODUCTIVE SYSTEM OF THE FLOWERING PLANT.

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On the Morphology of the Reproductive System of the Sertularian Zoophyte, and its analogy with the Reproductive System of the Flowering Plant. By Prof. E. Forbes of King's College, London*.

[With a Plate.]

The celebrated Grew, in his 'Idea of a Phytological History propounded,' among other recommendations of the study of vegetable anatomy, urges that "it may frequently conduct our minds to the consideration of the state of animals, as whether there are not divers material agreements betwixt them and plants, and what they are." The present communication has sprung out of such an application of phytological science.

The doctrine of the ideal metamorphosis of the leaf or vegetable individual in order to play a part in the reproduction of the species is now no longer a *quæstio vexata*, but an article of faith with the philosophical botanist. The mind of Linnæus discovered it, the spirit of Goethe divined it, and now that naturalists have been taught to trust in it by the experience of continued research, none but a botanical sceptic will venture to dispute it.

The doctrine of the vegetable individual is presented in its most precise form in the recent essays of Gaudichaud. His type or *phyton*, of an assemblage of which types the plant is composed, consists in itself of a limb or lamina, an ascending axis and a descending axis. Such a type is essentially respiratory and nutritive, and devoted to the life of the individual or congeries of individuals, and must be modified by a metamorphosis, usually retrograde, always ideal, ere it becomes a reproductive organ, and is devoted to the service and perpetuation of the species.

The plant, such as it presents itself usually to our view, is a composite being, made up of many such individuals, some serving to the nourishment of the composite individual or entirety, some metamorphosed either singly or in numbers, so as to assist in the propagation of the species of which that composite being is a member. That composite being is a commonwealth, all the members of which are fixed, though serving different purposes in the state. It is as truly a commonwealth as is the assemblage of bees in their hive or of termites in their hill. In such commonwealths we also see a division of physiological offices. Such commonwealths are to be found for the most part among beings included in the articulate sphere of the animal kingdom; that sphere which is itself representative of the vegetable kingdom, and obedient to the same great general laws.

Now as there are composite animals as well as plants, it becomes a curious and important inquiry to investigate the analogies of their parts and functions, and to see how far our *certain*

* Read at the Meeting of the British Association at York in Sept. 1844.

knowledge of the plant will enable us to throw light on the nature and regulating laws of the composite animal, at present very obscurely understood.

The present communication is intended to show, that in one tribe at least of composite animals, in the Sertularian Polypes, the arrangement and offices of individuals and of the parts of the animal entirely depend on the same laws which determine the arrangement and offices of the parts of the composite plant.

The Sertularian Polype is a branched and horny plant-like polypidom, the axis of which is filled with living pith and the branches studded with little cups or cells in which are seen the fleshy polypes, each a stomach with arms around its mouth for the seizing of its food. Each of these polypes is an individual distinct in itself and acting for itself, yet, besides that individual life, sharing in the common existence of the whole and obeying in reference to its brethren the laws which determine the characters of the species—the constant form and arrangement of the parts of the whole. If the axis should perish all the polypes must perish, but one or several polypes may perish without affecting the others or the life of the axis.

Now all such polypes are true nutritive individuals, devoted to the service of the composite individual or zoophyte of which the polypidom is as it were the bark. The zoophyte begins as a single individual, as the plant begins as a single phyton : polype after polype is built up and shares in the common interest with that first individual, as leaf after leaf is formed to serve in the same commonwealth with the first phyton. The normal type of the zoophyte is a simple stomach, that of the plant is a simple gill.

At certain periods in the life of the zoophyte there appear projecting from the axis or springing from its branches variously formed bodies, usually very dissimilar from the other parts of the whole, in which the ova are after a time formed. These have been called "vesicles," and many opinions have been entertained respecting their nature and origin.

By most naturalists they have been styled evolutions from the pith or fleshy axis *. They have been termed expansions of the stem †. Some have considered them female individuals ‡ or polypes of a different kind from the rest, inclosed in a larger cell §, and by some the vague term of ovariform buds has been applied to them ||.

Now if the parallel we have drawn so far between the plant and the zoophyte be carried out, these so-called "ovigerous vesicles" should be essentially either single individuals *ideally* metamorphosed into reproductive organs comparable to the monocarpous germens of plants, or a series of individuals joined to-

* Johnston, Grant. † Carpenter. ‡ Ehrenberg, Lovèn.
§ Carpenter. || Blainville.

gether and merged into each other in such a manner as to present the appearance of a unique body in which the ova are produced—comparable to syncarpous germens among vegetables. That such is the true view of their nature—however transcendental it may at first sight appear—I have convinced myself, and hope to prove it to the satisfaction of others by an analysis of the several forms of polype-vesicle presented in the family of *Sertulariadæ*.

All the 'ovigerous vesicles' with which I am acquainted may be distributed under six heads or kinds :—

1st. More or less lengthened pod-like bodies, ornamented with ribs and presenting a very complex aspect, such as we see in several species of *Plumularia*, as the British *Plumularia cristata* and the two species figured from Algoa bay. This is in reality the simplest and most easily understood form of vesicle, the form which has undergone least transformation, and which affords the readiest clue to the nature of these bodies. This pod is nothing more than a branch, the axis of which is usually shortened. In a remarkable species which I owe to the liberality of Mr. Bowerbank it retains its full dimensions. The pinnæ are turned in and united at their extremities, and webbed together by the transformed and expanded walls of the polype-cells. The pod has a ventral suture and a dorsal rib; the ventral suture corresponding to the line of junction of the extremities of the pinnæ, and the dorsal rib corresponding to the dorsal rib of the branch and identical in structure. The lateral ribs are the ribs of the pinnæ, and spring from the dorsal rib alternately, exactly as the pinnæ do from the unchanged branches. So slight is the change in this form of vesicle, that it is astonishing the contemplation of it (for it has been frequently carefully figured and described) had not opened the eyes of naturalists long ago to the true nature of these curious bodies.

2nd. Ovate or round berry-like bodies, studded with spinous processes more or less regularly whorled, such as we see in *Thoa muricata*. Bearing in mind the normal spiral arrangement of the parts of zoophytes on their axis (exactly as the parts of plants), supposing the shortening of the axis of a branch, the abortion of the greater number of its tubular cells and their conversion into spines, we can without much difficulty explain the essential nature of this form of vesicle.

3rd. Such wrinkled, ovate, coronated capsules as we see in *Sertularia rosacea* and *Plumularia pinnata*. These may be regarded as branches reduced to whorls of abortive cells, of which the rugæ are the only traces, whilst the whorl of terminal cells only exhibits a trace of its original nature and forms the corona. That many cells enter into the composition of these highly metamorphic vesicles is borne out by the fact that the vesicle of

Sertularia rosacea is provided with an internal framework, consisting of a slender axis and radiating processes, which is well seen after the expulsion of the ova. In an exotic species the composite nature of this form is further borne out by the fact of its vesicles dehiscing longitudinally on one side.

4th. Oblong, often triangular or flask-shaped, sometimes compressed vesicles, of which there are numerous examples among our native species of *Sertularia*, as *S. polyzonias, S. abietina, S. operculata, S. argentea*, and the genera *Thuiaria* and *Antennularia*. In these it would appear that all the cells had been metamorphosed in the highest degree, and that the midrib is suppressed for the formation of the ovarian cavity. In such species of *Sertularia* as have alternate cells, the termination of this form of vesicle is usually oblique; in those which have opposite cells it is straight. In *Antennularia*, where the cells are unilateral, the beak of the vesicle is turned to one side. These facts afford strong arguments in favour of the view I have taken of its essential nature, further supported by the arrangement of the vesicles in relation to the branches on a species from the Cape (which also I owe to Mr. Bowerbank), where the vesicles correspond to and represent the branches. See Plate X. fig. 10.

5th. The curious retort-shaped vesicles of *Thoa Beanii* and *Thoa halecina*, which appear to be formed out of a branch reduced to a single joint and a single cell, which merged into each other, form the ovarian capsule.

6th. The apparently simple vesicles of *Campanularia* and *Laomedea*, which may possibly be single cells dilated.

With the exception of the last-mentioned form of vesicle, of the true nature of which I have not yet satisfied myself, the varieties of form of these bodies, then, are all explainable on the theory that they are metamorphosed branches, either branches of the first order (primary axes), or of the second or third (secondary and tertiary axes). They are severally explainable on the supposition of union of parts, or of suppression of some of the elements of a branch, as of some of the cells, or of the central rib or axis, or of the internodes of that rib or axis. If these bodies were only ordinary cells changed, they would take the place of ordinary cells, and if unilateral on the axis, spring opposite the corresponding cells, but they do not: they arise unilaterally between the pairs of cells in the manner of branches.

From the foregoing considerations, the theory of the nature of the ovigerous vesicle in the Sertularian Zoophytes may be stated thus:—

The vesicle is formed from a branch or pinna through an arrest of individual development by a shortening of the spiral axis, and by a transformation of the stomachs (individuals) into an ovigerous placenta, the dermato-skeletons (or cells) uniting to form

a protecting capsule or germen,—which metamorphosis is exactly comparable with that which occurs in the reproductive organs of flowering plants, in which the floral bud (normally a branch clothed with spirally arranged leaves) is constituted through the contraction of the axis and the whorling of the (individual) appendages borne on that axis, and by their transformation into the several parts of the flower (reproductive organisms).

Whether the transformation in the case of the *Sertulariadæ* takes place *ab initio*, or after the individuals have performed for a time their normal function of stomachs, can only be answered by observations on the development of the living zoophyte.

Among the most convincing facts favouring the theory of vegetable morphology are monstrosities which every now and then occur, in which we find the floral axis and its appendages partially transformed into a folial axis and appendages.

Now if the views I have advanced be true, we should expect to find similar cases of monstrosity among Sertularian Zoophytes. I find on searching the records of zoophytology two figures which appear to represent monsters of the kind required.

The first is a figure of *Plumularia cristata* in Dr. Johnston's 'History of British Zoophytes,' pl. 19. f. 2, where a branch is represented as partially transformed into an ovigerous vesicle, whilst the polypes of the lower or basal extremity retain their normal character of nutritive individuals.

The second is a remarkable zoophyte described and figured by Dr. Fleming in the 'Wernerian Transactions,' vol. v. pl. 9, under the name of *Plumularia bullata*, in which branches bearing regular cells seem to spring out of vesicles, and to be changed in some instances into vesicles again.

The consideration of this subject naturally leads us to inquire how far it influences systematic zoophytology, and how far we should consider the form of the vesicle as of generic or specific value. I am inclined to regard its importance as generic. If so, a new arrangement of the Sertularian polypes is necessary, involving the dismemberment of the genera *Sertularia* and *Plumularia*.

A word on the classification of Zoophytes in general. The great groups of this class as at present constituted are not of equal value, which they should be if the acknowledged arrangements were strictly natural. This will be found on inquiry to arise from the including of the *Bryozoa* among Zoophytes proper, and the merging of the *Hydraidæ*, *Tubulariadæ* and *Sertulariadæ* in one order. The anatomical structure of the *Ascidioida* or *Bryozoa* removes them altogether from the class of *Zoophyta* into that of *Mollusca*, where they should form an order of *Mollusca Tunicata*, parallel with the group of compound *Tunicata* of which *Botryllus* and such forms are examples. The Zoophyta proper

may be divided into four very natural orders, the most prominent characters of which will be found in the arrangements of their reproductive system:—viz. 1st, Those which present the ovaries in the form of external bud-like bodies, including the *Hydraidæ* and *Tubulariadæ*. 2nd, Those which have the ovaries formed out of transformed branches or pinnæ, as the *Sertulariadæ*. 3rd, Those which have the ovaries included in the substance of the polypidom, as the *Asteroida*; and 4th, Those which have the ovaries forming a part of the internal constitution of the individual polypes, as the *Zoophyta Helianthoida*.

These four orders I regard as natural, and therefore equal in value.

This paper must be understood only as a sketch; circumstances having prevented my working out the inquiries upon which it is founded. But though the data are not numerous, I conceive they are sufficient to warrant my broaching the idea of the morphology of the polype-vesicle as presented to the Section at this Meeting. That idea is the clue by which we may be led to more perfect researches on this interesting and important subject, and such naturalists as are inclined to admit its truth must also see that it suggests new questions in the philosophy of zoology.

EXPLANATION OF PLATE X.

I. Vesicles of the first order. *Fig.* 1. Branch and vesicle of a *Plumularia* from Algoa bay (*a*, the vesicle; *b*, the branch). In this case the vesicle retains the dimensions of the branch, and is formed by the inflexion and union of the pinnæ and polype-cells. *Fig.* 2. Vesicle of another species of *Plumularia*, in which the axis is much shortened, while the pinnæ are all present. *Fig.* 3. Back of the same, showing the midrib and the manner in which the ribs of the vesicle spring from it, for comparison with *fig.* 4, representing part of a branch of the same species with its pinnæ and midrib. It is evident that the midrib of the vesicle is identical with the midrib of a branch, and that the denticulations of its lateral ribs correspond to the superior elongated teeth of the polype-cells of the pinnæ.

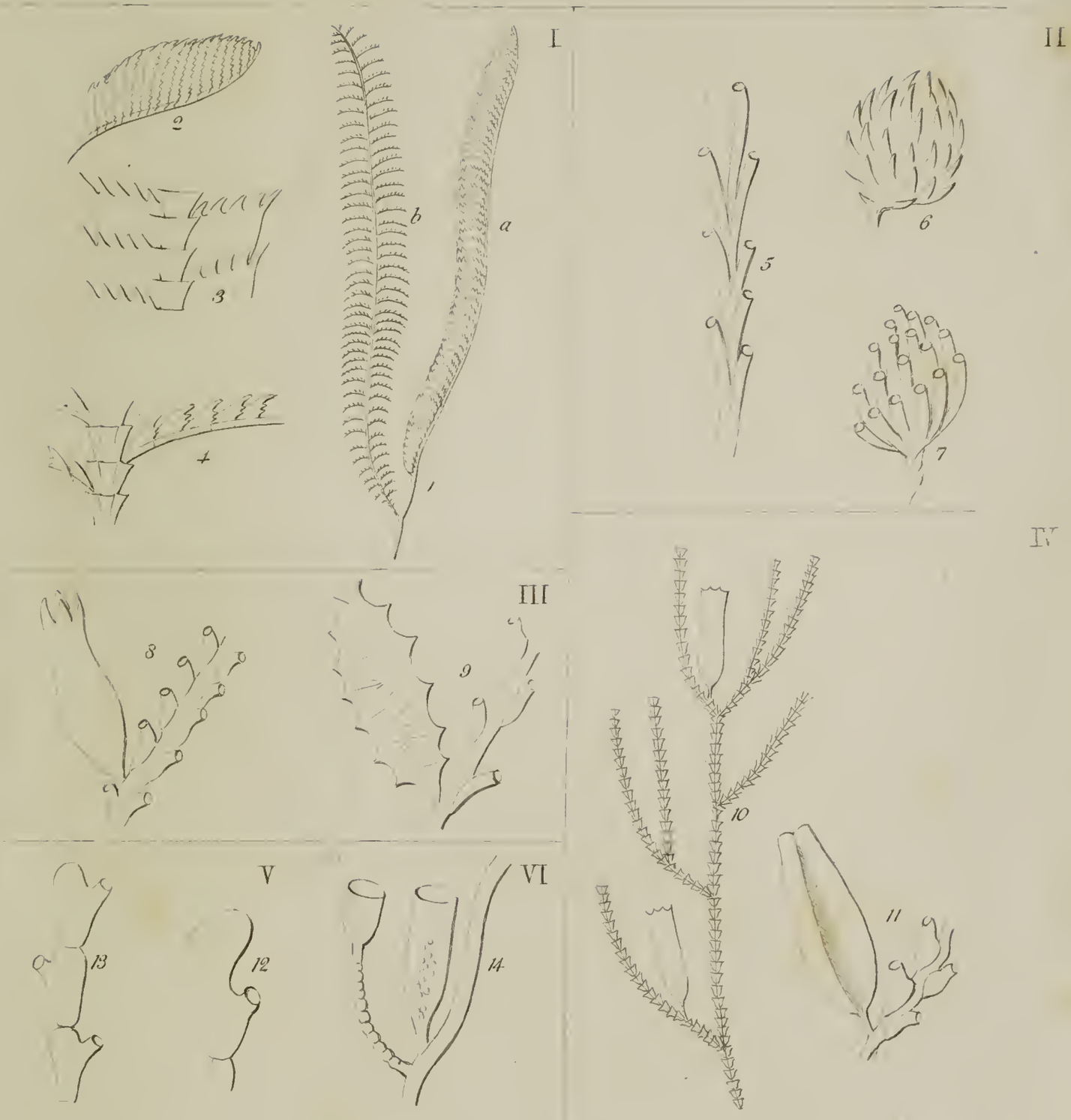
II. Vesicle of the second order. *Fig.* 5. Portion of a branch of *Thoa muricata*, showing the arrangement and form of the polype-cells. *Fig.* 6. Vesicle of *Thoa muricata*. *Fig.* 7. Idea of the structure of this form of vesicle, which is derived from the shortening of the axis and the whorling and transformation of the cells.

III. Vesicles of the third order. *Fig.* 8. Vesicle and branch of *Sertularia rosacea*. *Fig.* 9. Vesicle of a *Sertularia*, in which an internal framework and axis are seen after the exclusion of the ova.

IV. Vesicles of the fourth order. *Fig.* 10. A *Sertularia*, in which the secondary branches are grouped in pairs; in this specimen two of the branches are converted into vesicles, but retain their original position and relation to their twin branches. *Fig.* 11. Vesicle of a *Sertularia* belonging to this order, exhibiting longitudinal dehiscence.

V. Vesicles of the fifth order. *Fig.* 12. Vesicle, and *fig.* 13, part of the branch of *Thoa Beanii*.

VI. Vesicle of the sixth order. *Fig.* 14. Vesicle and polype-cell of a *Laomedea*.



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Morphology of Zoophytes.

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